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CONTENTS

The Editor's Page 323

Drying Research to be Continued.
Warp Sizing Research Committee and Place.
Testing of Textile Finishes.
Personals.
Science and Empiricism.

Some Physical Properties of Cotton Fibres Without "Growth Rings": A Note Relative to. Jerry H. Moore and Donald B. Anderson 325

Facts and Theories Concerning the Formation of Natural Silk, *A Textile Foundation Publication.* Werner Bergmann 329

Abstracts 343

Advertisements

Henry L. Scott Co., Providence, R. I. 322

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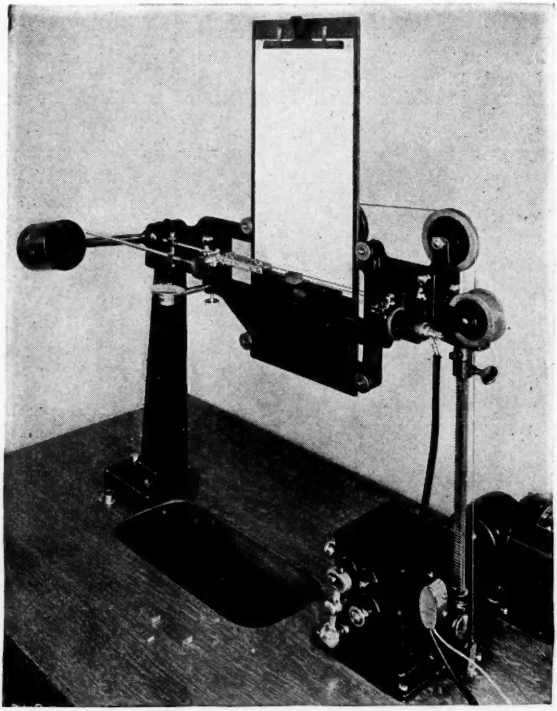

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Drying Research to be Continued

Subscribers Discuss Valuable Results and the New Program

SUBSCRIBERS to the Textile Drying Research, which has been in progress at the National Bureau of Standards under the auspices of U. S. I. T. R. since July 1, 1937, have recommended that the Institute undertake its refinancing for another year. This was the unanimous vote of subscribers' representatives who were in attendance at a meeting at the Bureau June 16, called by Director Lyman J. Briggs to hear reports of Dr. A. C. Walker, chairman of the Administration Committee, and Dr. J. G. Wiegerink, research associate, on the progress of the study and on the program for future work. Confirmation was sought and given of several new discoveries contained in the recently issued Progress Report No. 6 on "The Effect of Drying at Different Temperatures and Humidities on the Properties of Yarns." Certain of these results were contrary to previous opinion and theory, and are believed to have valuable practical applications.

The meeting was presided over by W. D. Appel, chief of the Bureau's Textile Section, and Chairman of the Institute's Research Council; following the meeting and after those present had inspected the new equipment, recording and control instruments for package drying, Mr. Appel conducted the party through Bureau laboratories.

Summary of New Program

The proposed program for the coming year's work on the drying project was summarized by Dr. Walker as follows:

(1) Drying Packaged Textiles.—The rate of drying of packages under varied conditions of temperature, atmospheric humidity, rate and direction of air flow through the package will be studied with the aid of the new equipment. The distribution of moisture in the package during and at the end of the drying cycle will be measured. Special emphasis will be placed on the time required, power consumed, and quality of the product. Packages which have been completely dried, or dried to some low moisture content, will be reconditioned in the same equipment, the rate of regain, distribution of moisture in the product, and quality of the product being observed. Drying and conditioning in one operation will be studied with special reference to the balance of economy and quality.

(2) Influence of Finishing Materials on Textile Drying.—Representative textiles in the condition in which they are usually dried commercially, that is, with sizing and finishing materials and small amounts of acids, alkalies, salts, etc., present on them, will be dried under varied conditions in both the old and the new apparatus. The data obtained will be correlated with the results already available for clean fibres.

New Subscribers and New Activities

At no extra cost to original subscribers the research year for this project has been extended from July 1 to October 1 to conform with the Institute's fiscal year, the addition of several new subscribers and the Institute's guarantee to cover any additional expense making this possible. Among the new subscribers are American Bemberg Corp., Bell Telephone Laboratories and United States Testing Co., Inc. The Institute will cooperate with subscribers in efforts sufficiently to increase the group and the revenue therefrom to the end that additional research workers may be employed, the program speeded up, and Director Wiegerink released sufficiently from detailed laboratory work to allow him to visit subscriber's mills and aid them in interpreting and in practically applying results of the research.

* * *

Warp Sizing Research Committee and Place

THE CANVASS for subscribers to the new research on the warp sizing of spun rayon and of cotton-spun rayon warps has been delayed until a program, place for the study and administration committee could be selected. Following several special meetings for this purpose Chairman W. D. Appel announced the selection of North Carolina State College Textile School, Raleigh, N. C., as the place for the study, the completion of the program, and the appointment of the following committee to administer the research: Perrin N. Collier, vice-president and research director, Callaway Mills, chairman; Dr. W. E. Yelland, who was research director of the Institute's previous warp sizing research, and Dean Thomas Nelson, of N. C. State College Textile School.

The selections noted are all tentative pending the completion of the research financing (now more than half subscribed), at which time a meeting of subscribers will be held and the latter will have the privilege of confirming or revising the recommendations of the Research Council.

It was the vote of a majority of those who attended the conference at which this research project was initiated, that it be conducted in the South and administered by a southern committee, the former warp sizing study having been conducted at Massachusetts Institute of Technology and administered by a northern committee. The Institute and the subscribers to this project are fortunate in securing the services of a committee so well equipped to supervise the practical and basic problems involved, and of an institution so well equipped for the work. Dean Nelson volunteered the services of his school as soon as the research was announced, and while his school is well equipped for the work, he has promised to add other equipment when and if needed.

A minimum of 20 additional subscribers are needed to complete the financing, organization and starting of this research. It is important that this be done in time to have the work start on October 1 with the next fiscal year of the Institute. The cost to each mill or firm ($150) is so small as compared with the basic and practical knowledge of efficient warp sizing to be obtained, and also with the services contributed to the project, that it should ensure early completion of the financing.

Those who have not received the program and other particulars should notify C. H. Clark, Secretary, U. S. I. T. R., 65 Franklin St., Boston, Mass.

(*Continued on page 328.*)

Some Physical Properties of Cotton Fibres Without "Growth Rings": A Note Relative to*

By JERRY H. MOORE and DONALD B. ANDERSON†

Summary

Cotton fibres of Mexican 128–6, grown under continuous illumination and uniform temperatures, and therefore without any evidence of lamellation of the cell wall have a lighter unit fibre weight, a lower breaking load per fibre, a higher percentage of thin-walled fibres, and approximately the same intrinsic strength as fibres of the same strain from plants grown in pots under field conditions during the same season.

Introduction

BALLS [3] demonstrated that swollen cross-sections of cotton fibres exhibit a pattern of concentric bands, or zones, of cellulose. Furthermore, Balls was able to demonstrate that the number of bands was correlated with the number of days during which the fibre wall increased in thickness. Because of this relationship these concentric zones are commonly designated as "growth rings." Subsequent work has shown that the "growth ring" pattern is a consequence of periodic variations in the temperature and light during the period of secondary wall deposition.[5] In an earlier paper the writers [1] described the successful production of cotton fibres that possess no "growth rings." This was accomplished by growing cotton plants under continuous artificial light at approximately constant temperatures. Aside from the complete absence of growth rings and the presence of a larger number of thin-walled fibres, the constant light fibre appears essentially similar to field grown cotton. Many of the constant light fibres are well thickened, however, and they all exhibit the same structure of spiral anastamosing cellulose strands that is so characteristic of field grown cotton fibre.[2] Cross-sections of cotton fibres produced under field conditions and under continuous artificial light are shown in Fig. 1.

Experimental

The details of the method used in producing cotton fibre free from growth rings have been discussed elsewhere,[1] and will not be repeated here.

* A part of the joint cotton research program of the Bureau of Plant Industry and the North Carolina Agricultural Experiment Station. Paper No. 105.

† Cotton Technologist, Agronomy Department, North Carolina Agricultural Experiment Station, and Agent, Bureau of Plant Industry, respectively.

In order to obtain cotton fibre with growth rings under conditions as nearly comparable as possible, plants of the same variety (Mexican Big Boll 128–6) were grown out-of-doors in 4-gallon pots. The pots were filled with the same kind of field soil that was used in the constant light experiments, and the plants were watered at intervals during the growing season. These pot-grown plants produced fibre which was indistinguishable in physical properties and in growth ring pattern from fibre of the same variety grown in the field during the same period of time.

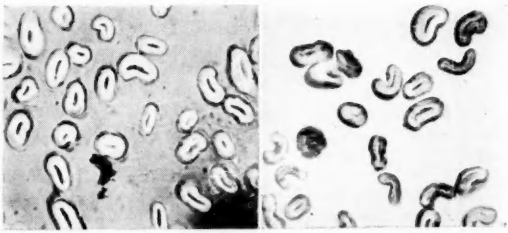

FIG. 1. Transverse sections of cotton fibres (Mexican 128–6 variety). Left, field grown; right, grown under constant light and uniform temperature.

The Comparative Study

In order to determine the influence of the growth ring pattern upon certain physical properties of the fibre, a comparative study was made of the growth-ring-free fibres developed under continuous light and of the fibres with prominent growth rings that were produced by pot-grown plants out-of-doors. The breaking load, unit weight, and intrinsic strength of each kind of fibre was determined experimentally.

All the fibre measurements were made in the fibre laboratory at North Carolina State College. During the tests the temperature was kept at 70° F. and th relative humidity at 65%. The whole fibres were broken one at a time on a machine of the balance type in such a way that three-eighths inch of the fibre at its midportion was exposed to the breaking load. Fibre weight per inch was determined by cutting and weighing representative one-half inch fibre segments and counting the number of fibres in the bundles.

Analysis of Data

The fibre data were studied by the analysis of variance method in order to show the significance of differences between field grown and constant light material. Table 1 presents in a summarized and simple form the statistical analysis of the fibre weight per inch, average breaking load per fibre, and the intrinsic strength of the two kinds of fibres. The figures for fibre weight per inch in this table indicate that the fibres produced under constant illumination are not as heavy as those produced under out-of-door conditions. This very significant difference in unit fibre weight is undoubtedly caused by the fact that the constant light material has a higher

TABLE 1

The weight per inch, average breaking load per fibre, and intrinsic tensile strength of cotton fibres of the Mexican 128–6 strain grown under natural day and night periods and also under constant artificial illumination. Analysis of variance. (Fisher)

	Sample A—Field grown material having growth rings in the fibre walls	*Sample B—Material grown under constant illumination and having no growth rings in the fibre walls	(a) Differences	(a) Least difference between treatments necessary for odds:		Odds of Experiment
				19 : 1	99 : 1	
Fibre weight per inch in milligrams	.00546	.00393	.00153	.00061	.0014	Odds are greater than 99 : 1 that there is a significant difference in the weight of the two samples
Number of fibres observed to determine fibre weight	2932	4130	—	—	—	
Average breaking load per fibre in grams	4.71	3.35	1.36	0.75	1.72	Odds are greater than 19 : 1 that there is a significant difference in the average breaking load per fibre of the two samples
Number of fibres observed to determine fibre breaking load	781	778	—	—	—	
Intrinsic fibre strength (ratio of average breaking load per fibre to average weight per inch).	862	852	10	123	284	Odds are less than 19 : 1; no significant difference in the intrinsic strength of the two samples

* Sample includes material grown from seed to maturity under constant illumination and also material grown under constant illumination from bolls which were first set and grown for several days under field conditions.

(a) "F" and "t" values and odds were obtained from Table X, p. 486, in Application of Statistical Methods to Agricultural Research, 1936, by H. H. Love. Odds of 19 : 1 indicate significant differences, while odds of 99 : 1 indicate highly significant differences.

.00546 − .00393 = .00153 = actual difference between treatments. Differences necessary for significance for odds of 19 : 1 and 99 : 1 are .00061 and .0014, respectively, for fibre weight. Similar comparisons are made for the other fibre properties.

percentage of thin-walled fibres than the material grown under out-of-door conditions. Such a difference is shown in photomicrographs of transverse sections of cotton fibres (Fig. 1). The data in Table 1 also show that the average breaking load per fibre of the constant light fibres is significantly lower than that of material grown under natural light conditions. Balls [4] defines intrinsic strength as the ratio of average breaking load per fibre to average unit weight. The intrinsic strength then indicates the relative ratio of total fibre breaking load per cross-section of a yarn strand or skein in different cottons. The data in Table 1 do not show any significant difference in the value for intrinsic fibre strength, since the two values are almost the same. The breaking load per fibre is lower in the constant light material, but because of a lighter unit weight the intrinsic strength is similar to that of normal material.

References

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3. Balls, W. L. The existence of daily growth rings in the cell wall of cotton hairs. *Proc. Roy. Soc., B95,* 72–89 (1919).

4. Balls, W. L. Studies of Quality in Cotton. London. 1928.

5. Kerr, T. The structure of growth rings in the secondary wall of the cotton hair. *Protoplasma, 27,* 229–241 (1937).

(*Continued from page 324.*)

Testing of Textile Finishes

L. B. ARNOLD, JR., chairman of the Special Committee for Testing of Textile Finishes, sponsored by Committee D–13 on Textile Materials of the American Society for Testing Materials, announces the appointment of Dr. Edwin C. Dreby as research associate. The research program, which will be carried out at the National Bureau of Standards, will emphasize methods for the physical evaluation of the "handle" of textiles, and will include test methods for certain other types of finishes. The present subscribers to this research program are as follows: American Viscose Corp., Cranston Print Works Co., E. I. du Pont de Nemours & Co., Geigy Company, Inc., Hart Products Corp., Hercules Powder Co., National Oil Products Co., Sandoz Chemical Works, Inc., Scholler Brothers, Sears, Roebuck & Co.

* * *

Personals

Franklin W. Hobbs, president of Arlington Mills, Lawrence, Mass., and Chairman, The Textile Foundation, has been president, ever since his graduation from Massachusetts Institute of Technology, of the class of 1889 which celebrated its 50th anniversary last month.

(*Continued on page 342.*)

Facts and Theories Concerning the Formation of Natural Silk

By WERNER BERGMANN*

A Textile Foundation Publication

Introduction

IN most of the standard textbooks on natural silk the subject of its formation has been treated in a rather superficial manner only. Since many of these textbooks are also comparatively antiquated, what little information they contribute to the subject of silk formation has been largely outmoded by the results of investigations which have been carried out during recent years. For the past thirty years there has appeared a number of studies of fundamental importance, which permit us to draw a rather satisfactory, though not completely detailed picture of the processes leading to the formation of silk. Many of these more recent investigations, however, have been published in such foreign journals as are not readily available in most libraries, and they have consequently escaped the attention of many investigators interested in this subject. It is the purpose of the present review to remedy this situation. An attempt has been made to extract from numerous publications the more significant facts as well as theories concerning the formation of silk and to coordinate them in a critical manner. Wherever possible, the older theories, which have been given credence in many textbooks, have also been mentioned and contrasted with more recent conceptions, based on the latest developments of research.

Many of the older textbooks, such as *Die Seide* by Silbermann (1897) contain excellent detailed descriptions of the silk producing organs of the silkworm Bombyx mori. These descriptions are essentially correct and require only slight modifications in the light of more recent studies. In order to facilitate the understanding of the discussion of the formation of silk, a few of the facts concerning the anatomy of the silk producing organs have been reviewed in the following paragraphs.

The Anatomy of the Silkglands

The silk producing apparatus of the silkworm Bombyx mori consists of a pair of glands, located in the ventral part of the body (see Fig. 1). These glands are long tubular bodies, which end blindly in the rear of the insect and run into a common duct near the head of the worm (see Fig. 2). Each gland can be divided into three sections, the posterior (a–b), the middle (b–c) and the anterior (c–d) division. These sections are often referred to as the secretory part, the reservoir and the excretory tube.

* Senior Research Fellow of the Textile Foundation (1938–1939) operating in the Sterling Chemistry Laboratory, Yale University, New Haven, Conn.

With the exception of the latter these terms are misleading, because the secretory activity of the gland is not restricted to the posterior division but extends through the entire length of the middle section.

The posterior part of the gland is characterized by numerous (from 12 to 15) windings. It is from 20 to 30 cm. long and about 1 mm. thick. The posterior part leads gradually into the middle section, which measures 8–10 cm. in length and 2–3 mm. in diameter. As shown in Fig. 2, the diameter is largest in the section between the first and second winding. The anterior part of the gland consists of the excretory tube which is from 3–4 cm. long and from 0.3–0.4 mm. thick. This tube goes through a few windings before it joins its counterpart coming from the other gland to form the common duct.

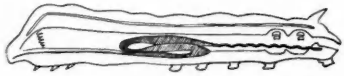

FIG. 1. Length section through silk worm showing location of silk gland (shaded area).

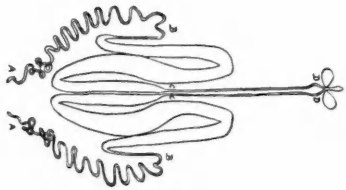

FIG. 2. Silk gland of Bombyx mori. A–B posterior part, B–C middle section ("reservoir"), C–D excretory tubes.

In mature silkworms the silk glands occupy a considerable part of the body cavity. During their rapid growth in the course of the fifth age of the worm, the glands push the alimentary canal more and more toward the dorsal wall and compress it in such a manner as to give it a band-like shape.

The walls of the gland consist of three layers. The outside layer has been named tunica propria. Until quite recently the tunica propria had been regarded as a special membrane. Lesperon,[16] however, showed that it is merely the membrane of the cell walls. The innermost layer, the tunica intima, on the other hand, is a truly special membrane. Between the tunica propria and the tunica intima lies a single layer of very large cells. These cells are of very uniform size and of hexagonal shape. Some of them are large enough to be visible to the naked eye. One pair of such cells suffices to form a ring around the lumen of the gland (see Fig. 3). The size of the cells varies with their location in the gland. In the posterior part they are about 0.3 mm. long and 0.1 mm. wide. In the middle part the dimensions are 3.7 mm. and 0.5 mm. respectively. Under the microscope the cells show a granular protoplasm with radial stripes (Fi-

brilli). They contain numerous nuclei in various degrees of branching. In the cells of the middle and posterior part the nuclei appear to be almost dissolved.

The silk glands are organs of great physiological activity. The oxygen necessary to maintain this activity is supplied by a system of tracheal tubes surrounding the glands. These tubes send out delicate branchlets directly into the silk producing cells (see Fig. 4). The respiration of the gland has recently been studied by Ashbell,[1] who found that the respiratory activity was highest in the posterior part of the gland, which is also the region of the greatest secretory activity.

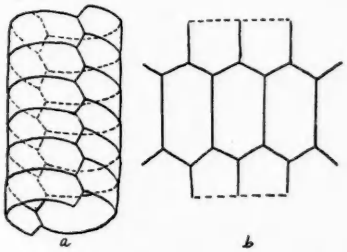

FIG. 3. a and b. Pattern of cells forming the cell wall of silk gland. (Modified drawing according to Silbermann.[23])

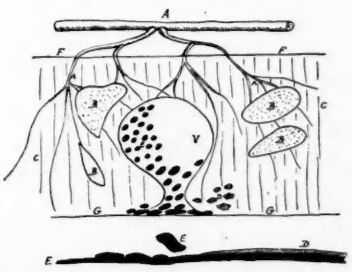

FIG. 4. Section through a secretory cell of the posterior section of the gland. A, tracheoles; B, nuclei; C, fibrillae; D, sericin ?; E, fibroin; F, tunica propria; G, tunica intima; V, vesicle. (Modified drawing according to Yamanouchi.[30])

The Secretion of Silk

Natural silk consists of two major components, the fibroin which forms the center of the fibre and the sericin which forms its outside layer. For some time it was thought that fibroin was the sole product secreted by the worm, and that sericin was formed by the atmospheric oxidation of the fibroin. This view however became untenable when it was discovered

that sericin was already present in the glands. Its presence there can be demonstrated by the use of certain aniline dyes, for which the two components of silk have different affinities. Sericin for instance can be stained red with acid fuchsin, a dye which has little visible effect on fibroin. Fibroin, on the other hand, can be dyed deep blue with Bleu de Lyon or deep green with methylgreen, dyes which leave the sericin unstained. By the use of the proper staining methods it is therefore possible to differentiate between fibroin and sericin wherever they are present in the gland.

While various conflicting theories concerning the formation of sericin have been advanced during the past fifty years, investigators have almost unanimously agreed, that fibroin is produced by the posterior part of the gland. The presence of small droplets of fibroin in the cells of the posterior section can easily be demonstrated with the help of a suitable vital stain. Yamanouchi [30] made the very interesting discovery that the fibroin droplets always occurred in small vesicles, and that outside of these not even the smallest trace of fibroin could be recognized (see Fig. 4). This observation led Yamanouchi to the conclusion that the cell protoplasm does not produce the fibroin proper. It produces a precursor which does not change into fibroin until it has been brought into the vesicle. It remains to be ascertained how much the nuclei of the cells are instrumental in the preparation of this "pro-fibroin." As soon as a certain amount of fibroin has been accumulated in the vesicle, cell wall and tunica intima burst open to release the fibroin into the lumen of the tube. Here the droplets join other fibroin particles to form a column, which, by pressure, supplied at least partly by peristaltic movements, gradually advances toward the middle section.

So far as the formation of sericin is concerned there exists no such general agreement as in the case of fibroin. One group of investigators held that the sericin was formed by interglandular oxidation of the fibroin. Blanc [3] believed that this oxidation took place during the passage of the fibroin through the middle section of the gland. Tanaka [24] arrived at similar conclusions. He maintained in addition that fibroin was secreted by the posterior and middle section of the gland, and that the conversion of fibroin into sericin did not only take place in the glandular cavity, but also occasionally inside the cells. The air supplied by the tracheal capillaries was believed to be the oxidizing agent.

Other investigators held that sericin and fibroin were secreted as different substances. Gilson [11] believed that they were possibly secreted as a mixture, which was later separated into its components by some ill-defined process. Yamanouchi [30] in a very illuminating publication maintained that the production of fibroin was restricted to the posterior part of the gland. Sericin, however, seemed to be secreted by both the posterior and middle section. He was confident that his methods of staining had demonstrated convincingly that the cells of the posterior section are able to produce both fibroin and sericin simultaneously. Fibroin, as has already been said, is produced in the vesicles deeply embedded in the protoplasm. Sericin is secreted nearer the inner cell wall and shows a somewhat granular structure (see Fig. 4). Yamanouchi [30] also maintained that there is no distinct separation of the two silk components during the early stages of silk production. Later, however, the sericin and fibroin particles begin to combine with their own kind and to separate into two distinct layers. In more advanced stages this separation is facilitated by

successive alternation of the intensity of the fibroin and sericin secretion. At the height of the fibroin secretion little or no sericin is produced and vice versa. In contrast to the posterior part, which according to Yamanouchi can produce fibroin as well as sericin, the middle section secretes sericin only. In the cells of this section, however, the sericin is not produced in granular form, but as a homogeneous mass (see Fig. 5). When discharged from the cells this newly formed sericin covers the sericin cortex of the silk column advancing from the posterior part of the gland.

Yamanouchi's observations therefore seem to indicate the existence of two types of sericin, the granular type of the posterior and the compact

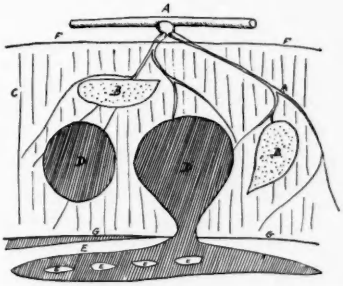

FIG. 5. Section through a secretory section of the middle section of the gland. A, tracheoles; B, nuclei; C, fibrillae; D, sericin; E, fibroin; F, tunica propria; G, tunica intima. (Modified drawing according to Yamanouchi.[30])

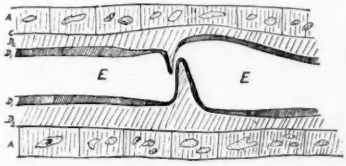

FIG. 6. Length section through middle section of gland. A, layer of cells; B, nuclei; D_1 and D_2, layers of sericin of different staining capacity; E, fibroin. (Modified drawing according to Yamanouchi.[30])

type of the middle section. The possible existence of different types of sericin was also indicated by the fact that the staining of the sericin cortex revealed two or three layers, easily distinguishable by the degree of intensity of color (see Fig. 6). Yamanouchi held, however, that these variations in staining capacity were not caused by a difference in chemical composition, but merely by a difference in density. Although this explanation may be correct, the possibility of actual differences in chemical composition between the various layers of sericin is not altogether elimi-

extra pair of rudimentary silk glands. Cornalia [4] believed that the glandular secretion furnished the silk fibre with its characteristic film of wax, while Helm [12] regarded it as a glue combining the two columns of silk and Blanc [3] as some agent facilitating the passage of the silk through the common duct and the spinneret. Gilson [11] made the rather plausible assumption that the secretion of the glands of Filippi was instrumental in bringing about the transformation of the liquid silk of the silk gland into the solid silk fibre. It will be shown in one of the later chapters, however, that this theory also is not quite satisfactory.

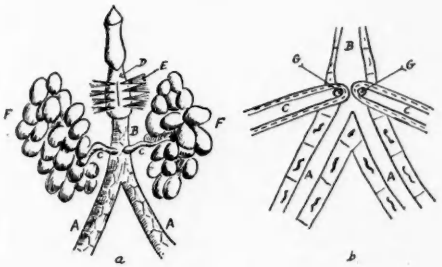

FIG. 7. Glands of Filippi. A, excretory tubes; B, common duct; C, tubes from Filippi's glands; D, silk press; E, muscles; F, Filippi's glands; G, function of C and A. (Modified drawing according to Silbermann. [23])

The location as well as the small size of the glands makes their isolation extremely difficult. For this reason a systematic study of the chemical nature and activity of the glandular secretion has not yet been possible. It seems quite logical to assume that the glands play some rôle in the formation of the silk fibre. As long as experimental data are not available, however, any theories concerning such a role must necessarily remain of somewhat doubtful value.

The Silk Press

After a short passage through the common duct the silk, coming from the glands, reaches an interesting organ, which plays a very important part in the formation of the fibre and which is generally referred to as the silk press (see Figs. 8, 9). In a cross-section the lumen of the press shows the shape of a half moon. Strong muscles are attached to the wall of the tube to facilitate a widening or narrowing of the lumen. The silk press regulates the shape and the thickness of the fibres, and it can also cut them off completely.

It is generally known that the diameter of the fibre used in the construction of the cocoon is gradually decreasing from the beginning to the end of the fibre. This phenomenon has been attributed by Gilson [11] to a gradual relaxation of the muscles connected with the silk press. The progressive tiring of the muscles causes a gradual shrinking of the lumen and consequently a flattening of the fibre. The silk press, therefore, exerts

nated. One of the sericin layers observed by Yamanouchi is possibly identical with the layer of "mucoidin" which Blanc[3] considered to be different from sericin and fibroin. Yamanouchi[30] also made the interesting observation that the sericin does not always form the cortex of the silk column, but that it may occasionally grow deep into the axial fibroin (see Fig. 6). This is quite important, for it is evident that a silk fibre of such abnormal distribution of sericin must give a faulty product during the technical degumming process.

A third group of investigators (Lidth de Jeude,[27] Verson and Quajat,[28] Raulin and Siccard[22]), finally maintained that sericin and fibroin are secreted quite separately, the former in the middle section and the latter in the posterior part exclusively. The most recent investigation on this subject has given this assumption additional support. Machida[18] severed various sections of the gland and left them separated from each other in the body cavity. In spite of these operative measures silk secretion continued in the isolated sections. On reopening the worms after a certain lapse of time, Machida found that an isolated posterior part contained fibroin only, and that the secretion of sericin had taken place through the entire middle section of the gland. Like Yamanouchi,[30] Machida[18] observed differences in the staining capacity of the sericin, which he believed were caused by the presence of two or more distinctly different types of sericin.

Whether Machida's observations have supplied the final answer to the controversial subject of the secretion of sericin must be left to future investigations. At present it appears beyond doubt that fibroin is produced by the posterior part only, and that sericin is secreted along the entire length of the middle section. It is somewhat uncertain whether sericin can also be produced by the posterior section. Definite evidence has been advanced which shows that sericin lacks the uniformity of fibroin, as indicated by the differences in staining capacity. Whether these differences are of physical nature, such as variations in density or whether they are indications of chemical differences, are questions for which a completely satisfactory answer has still to be found.

The Glands of Filippi

When the worm begins to spin the silk mass is transported by way of the excretory tubes (see Fig. 1, c–d) into the common duct, which forms a narrow tube with rather thick and solid walls. On entering the common duct the two silk columns do not coalesce, but retain their shape and are merely glued together.

During their entrance into this duct the two columns are brought into contact with the secretion of a pair of accessory glands. These glands which are generally referred to as the "glands of Filippi,"[20] or by certain French authors[16] as the "glands of Lyonet," consist of an accumulation of highly vacualized cells intimately connected among each other (see Fig. 7). The cavities of these cells contain a rather thickish liquid, which is secreted directly into the lumen of the common duct through a short channel (see Fig. 10). Almost nothing is known about the composition and activity of this secretion. None of the various theories on the purpose of these glands which have been advanced so far, have been shown to be completely satisfactory. Tichomirov[25] regarded the glands of Filippi merely as an

most serious objection to this theory is based on the observation that the solidification of silk can also be accomplished in the absence of the glands of Filippi.

Artificial solidification of liquid silk has been practised for several hundred years in the manufacture of the so-called "Fils de Florence" or "Crins de Florence." For the preparation of such fibres the silk glands of worms are used, which have been thoroughly soaked in acetic acid. Under the influence of the acid the liquid silk assumes a dough-like state. The gland is then taken at each end and stretched as long as the plasticity of the dough permits. The fibres obtained in such a manner are from 15–20 inches long. They possess great tensile strength and are used as fishing lines or surgical sutures.

Dubois[7, 8] considered the solidification of silk as a process analogous to the coagulation of blood. He believed that it was caused by the interaction of two compounds which he named the fibroinogenic and fibroinoplastic substances in analogy to the coagulation of blood. This theory, however, was not based on any experimental evidence, and it has been completely discredited by later investigators.

Foa[10] (1912) deserves the credit for placing the study of the solidification of liquid silk on a thorough experimental basis, for introducing the concepts of colloidal chemistry into it and for advancing a theory concerning its causation which has been shown to be very satisfactory.

In order to obtain a clear picture of the physical state of the fibroin in the gland, Foa first turned his attention to a systematic study of an aqueous solution of liquid fibroin. This solution was obtained by washing freshly extirpated glands rapidly with water, cutting them into small pieces, grinding them with sand in a mortar and extracting the mixture with distilled water. By this method solutions were obtained which were clear and which showed a gum-like consistency at higher concentrations. Left to themselves the solutions underwent coagulation between three and twenty-four hours.

Boiling of the aqueous solutions did not bring about coagulation. In the presence of acetic acid, however, they gelatinized instantaneously. Under the ultramicroscope solutions of liquid fibroin showed Brownian movements, which was indicative of the colloidal nature of the fibroin. If an electric current was sent through such a solution, the silk particles migrated to the positive pole, where they were precipitated. The fibroin present in solution therefore behaved like a negative colloid. The filtrate of an ultrafiltration of a solution of liquid fibroin did not give a precipitate with acetic acid, nor the biuret reaction, and it showed the absence of colloidal material under the ultramicroscope. Like a true colloid therefore the fibroin could be separated from its solvent by ultrafiltration.

In analyzing his observations Foa came to the conclusion that liquid fibroin obtained from the glands of living worms upon dissolution in water behaves like a negative colloid, which gives the biuret reaction. It can solidify spontaneously, is precipitated quantitatively by acetic acid and does not coagulate on heating.

Having obtained concrete information on the physical state of liquid fibroin Foa then proceeded to disprove some of the older theories on the solidification of silk and to advance a new and satisfactory theory of his own. Like Dubois,[7, 8] Foa[10] rejected the theory which held the presence of

a profound influence on the diameter ratio of the silk fibre, a factor which has recently been shown to be of great importance in the dyeing of silk fabrics.

The main importance of the silk press lies in its participation in the process of the solidification of silk, which will be discussed in the following chapter.

The Solidification of Liquid Silk

The silk of the middle section of the silk gland, the so-called reservoir, is physically quite different from the silk of which the cocoon has been constructed. In contrast to the firmness of the "cocoon silk" the "gland silk" is a rather viscous liquid. Another striking difference lies in the solubilities of the two types of silk. The fibroin of liquid silk is very soluble in water (Ludwig) [17] or certain aqueous salt solutions such as 5–10% sodium chloride or potassium carbonate solution (Dubois).[5–6] The fibroin

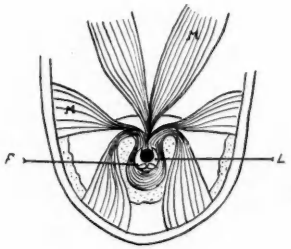

FIG. 8. Cross-section through silk press. M, muscles; L, lumen; F, silk fibre. (Modified drawing according to Silbermann.[23])

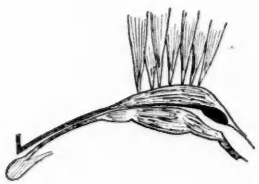

FIG. 9. Length section through silk press. (Modified drawing according to Silbermann.[23])

of the silk fibre on the other hand is quite insoluble in these agents. Curiously enough the solidification of silk affects the solubility of sericin in a manner opposite to that of fibroin. The sericin of the silk fibre, as it is well known, is quite soluble in weak alkaline solutions. The sericin of the silk gland, however, is quite insoluble in alkaline solutions, as for example, 10% potassium carbonate (Silbermann).[21]

Between the time the silk has left the silk gland and the time it plays its part in the construction of the cocoon, a change of fundamental importance has taken place: *the silk has solidified.* The possible causes of this striking alteration of properties have been the subject of considerable discussion during the past fifty years. It has already been mentioned in one of the previous chapters that Gilson [11] considered the secretion of the glands of Filippi as instrumental in bringing about the solidification of liquid silk. Due to the lack of sufficient experimental evidence it has not yet been possible to prove or disprove Gilson's theory completely. The

air prerequisite for the solidification of silk. He also demonstrated that silk spun under water did not differ essentially from the normal product, and that consequently desiccation in the presence of air could not be the cause of solidification.

Foa also criticized the theory which regards the coagulation of liquid fibroin as an enzymatic process. He pointed out that in case an enzyme was instrumental in bringing about the coagulation, one should assume that it would be destroyed by vigorous heating, and that a boiled solution of liquid fibroin should not undergo spontaneous coagulation. This, however, is not the case. Boiled solutions of liquid fibroin undergo spontaneous coagulation as rapidly if not more rapidly than unboiled solutions. Addition of potassium cyanide, which paralyzes enzymes, to solutions of fibroin does not prevent their coagulation. Potassium cyanide retards coagulation to a certain degree, but this behavior is quite common for a great variety of salts, as for instance potassium oxalate, sodium fluoride, sodium chloride, barium chloride, barium nitrate and ammonium chloride.

Having eliminated the possible causes mentioned in the previous paragraphs, Foa arrived at the conclusion that the solidification of silk, which takes place during the spinning process, is produced by purely mechanical action, namely by the stretching and pulling which the silk has to undergo after it has left the gland.

Foa's observations have been confirmed and augmented by Hirazuka,[14] Nakajima,[19] Hirasawa,[13] Ongaro[20] and others. These investigators found that liquid fibroin is a concentrated colloidal solution composed of a dispergating medium which is non-protein in nature and the dispergated, very soluble, negative colloid. Liquid fibroin is an irreversible colloid, it is very unstable and tends to coagulate. This coagulation can be accelerated by mechanical action, such as stirring, rubbing, pressure or passing through a capillary. The presence of hydrogen ions favors coagulation, the optimum being at pH 1.3 and 3.9. The latter point is very close to the isoelectric point of sericin. In the silk worm, coagulation takes place during the passage of the silk through the silk press and the spinneret.

Foa's theory of the mechanical solidification of silk has also been supported by von Weimarn,[29] who regards the coagulation of liquid fibroin merely as one of the numerous types of "coagulation by motion" which is quite common among natural products.

The new concept of the mechanical cause of the solidification of liquid silk throws a new light on the purpose and action of the silk press. It has already been pointed out that the silk press regulates shape and thickness of the fibre. It has now become evident that it is also instrumental in bringing about the solidification of the silk. In the liquid silk the direction of the fibroin particles is chaotic. When forced through the excretory tube, the common duct and especially through the narrow lumen of the silk press, these particles become oriented in the direction parallel to each other. This process is quite similar to the orientation of logs floating down the river. After the silk particles have become oriented in such a manner they have more chance to become united at the points of maximum cohesion and the silk becomes solid.

It must be emphasized that the discussion on the solidification of liquid silk which has been presented in this chapter refers exclusively to the fibroin part of the silk fibre. As has already been pointed out in the in-

troduction to this chapter, the sericin also undergoes very definite changes during the spinning process, of which the most important one is its transformation from an insoluble to a soluble material. The cause and the general character of this change remain still to be investigated. The sericin of the freshly spun silk fibre is a slightly viscous substance, which does not solidify completely until several hours afterwards. This viscosity permits the fibres to become slightly glued together, a process which contributes to the compactness and firmness of the cocoon.

The Biological Significance of the Secretion of Silk

At first glance it seems quite logical to assume that the primary purpose of the secretion of silk by the worm is to provide the insect with a protective shell during its pupal stage. This simple explanation, however, has been questioned by Pigorini,[21] Lesperon [16] and other workers in this field. Pigorini considers the use of the silk for the construction of the cocoon as only of secondary importance. In his opinion the prime importance of the secretion of silk is the elimination of certain toxic waste products by the worm. In other words, according to Pigorini, the silk in the silk gland represents an accumulation of protein-like, toxic waste products. If this assumption is correct, then silk must be considered not as a product of secretion but of excretion.

It is, however, often very difficult to differentiate accurately between secretory and excretory phenomena. Theoretically at least a secretion refers to the elaboration of a very definite substance not normally produced by the metabolic processes. Secretory cells draw from their surroundings certain substances which they utilize in the preparation of a new substance, which then leaves these cells to fulfill a very definite purpose. Excretion on the other hand refers to the elimination of waste products. Excretory cells draw from their surroundings toxic or waste material, which is subsequently eliminated into one of the excretory channels. Excretory and secretory products, however, are often analogous and make a clear distinction extremely difficult.

The question of the secretory or excretory nature of silk is not only of purely academic interest, but also possesses practical significance. If silk can be shown to be primarily the product of the elimination of toxic or waste substances of the nature of proteins, then the addition of such substances to the diet of the silkworm should conceivably increase its silk production. If on the other hand silk is to be considered as a product of secretion, that is to say, if it is produced for the sole purpose of providing protection for the insect during its pupal stage, then the worm will secrete only as much silk as is required. If such is the case, addition of protein material to an otherwise ample diet would not bring about an increase in the silk production.

Two lines of investigation have been undertaken to decide between the secretory and excretory nature of the silk, namely the study of the protein metabolism of the silkworm, and the study of the toxicity of the silk products to the animal.

Pigorini [21] raised silkworms on a diet of mulberry leaves to which certain amino acids had been added. He believed that his experiments indicated an increase in the silk production of worms fed on such diet, and he

consequently concluded that the silk was of excretory nature. Later investigators repeated these experiments with a great variety of proteins; the results obtained in these investigations are so undecisive as to make a definite conclusion impossible.

The study of the toxicity of the silk to the silkworm has been carried out along two different lines. Umeya [26] found that worms from which the glands had been removed died shortly before or during pupation. He consequently concluded that the glands were essential for the growth of the worm. Umeya also observed that worms from which the spinnerets had been removed on the first or second day of the last larval stage failed to reach the pupal stage or pupated with difficulty and died soon afterwards. In all cases death seemed to be due to an overseeretion of the silk fluid into the body cavity.

Couvreur and Clement [5] tried various methods of achieving a retention of silk in the mature worm. Their experiments, however, either failed entirely or gave inconclusive results. More successful were the experiments of Lesperon [16] who succeeded in preventing the worms from spinning by a cauterization of the excretory tubes. Many of the worms which had been treated in such a manner survived and pupated. The size of the pupae was considerably above normal. Most pupae, however, died soon after metamorphosis and only two survived and gave moths. Lesperon concludes from the results of his experiments that the silk is not necessarily toxic to the insect.

The experiments on the toxicity of silk to the silkworm cannot contribute to the solution of the problem of the secretory or excretory nature of the silk, whatever their results may be. Even if it could be demonstrated beyond doubt that the silk is definitely toxic to the worm, it would not be permissible to interpret this result in favor of the excretory origin. As long as a product of secretion is performing its function at the place which nature has assigned to it, it is harmless. If the secretion, however, is interfered with in one way or another, we must expect the organism to react unfavorably to this disturbance. A secretory product which has been dislocated from its sphere of action might well behave as a toxic substance.

The cocoon itself is not absolutely necessary for the development of the insect. A worm which has been deprived of its cocoon soon after its perfection will still pupate and the ensuing chrysalis will still develop into a moth. It is certain, however, that under natural conditions the chances of the survival of the insect are greatly increased by the presence of the cocoon, which forms such a splendid protection against the adversities of climate and the attacks of animals.

Conclusions

The investigations which have been discussed in the preceding paragraphs have significantly increased our knowledge of the functioning of the silk-producing organs of the silk worm Bombyx mori. Many more fundamental studies, however, will be required, before the picture of all the processes which lead to the formation of silk is complete. The difference in the biochemical processes by which fibroin is produced in the cells of the posterior section and sericin in the cells of the middle section of the gland, is still very obscure. We do not know whether all the various amino

acids which are used in the synthesis of the silk have been derived from the proteins of the mulberry leaf or whether they are produced by a special mechanism in the worm itself. Some investigations along this line have recently been carried out by Holtzmann.[15] This author found that the intake of tyrosine in form of leaf proteins during the life history of the worm is sufficient to account for the high proportion of this amino acid in the silk produced as well as the tyrosine present in the chrysalis. It is unnecessary therefore to suppose a special tyrosine synthesis on the part of the worm.

Another interesting question still waiting for an answer concerns the ways and means by which the wax is added to the silk. This minor component of raw silk amounts to 0.4–1% of the total (Bergmann).[2] It would be of interest to know whether the wax is already present in the gland before the worm begins to spin or whether it is deposited on the silk during the spinning process. More information is available on the origin of the yellow pigments which characterize the silk of certain races of Bombyx mori. This subject will receive special attention in a separate communication devoted to a discussion of the natural pigments of raw silk.

One of the most important problems in regard to the formation of the silk which still remain unsolved is the biological significance of the glands of Filippi. As long as a satisfactory explanation of the functioning of these rather mysterious glands has not been found, the picture of silk formation must necessarily remain incomplete.

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(*Continued from page 328.*)

Dr. Harold DeWitt Smith, treasurer of the A. M. Tenney Associates, New York City, was a guest speaker at the Annual Conference of The Textile Institute at Bath, Eng., May 31–June 2, the subject of which was "Properties, Production and Utilization of New Fibres." Dr. Smith contributed a paper on Teca, the crimped staple fibre made by the Tennessee Eastman Corporation, and samples of Teca fibre, yarns, and fabrics were exhibited.

* * *

Edward R. Schwarz, professor of textile engineering at M. I. T., and vice-president of U. S. I. T. R., was one of the guest speakers at the recent meeting at Myrtle Beach, S. C., of the Southern Textile Association. Textile research and its value and accomplishments was his subject there, as it was at the recent research week meeting of the New England engineering societies in Boston, and in a broadcast previously over WEEI under the auspices of the Associated Industries of Massachusetts.

* * *

Science and Empiricism

Fabric fuel tanks for airplanes, known as Mareng fuel cells, and impregnated with "neoprene," are announced by the Glenn L. Martin Co. to be leak-resistant and practically indestructible by vibration.

* * *

Blends of casein and viscose rayon fibres spun and woven on cotton machinery in Lancashire, Eng., mills are mentioned as having interesting possibilities because of their wool-like handle and their relative cheapness as compared with all-wool products. Blends of 67% viscose staple and 33 casein staple are noted, the price of the latter being about 29¢ a pound.

Abstracts

Committee on Abstracts and Bibliography:
E. R. Schwarz, Chm., Dr. E. J. Saxl, C. H. Clark.

Members of U. S. Institute for Textile Research desiring complete copies of articles abstracted may avail themselves of any or all of the following services by addressing the Secretary:

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Address, C. H. Clark, Sec., 65 Franklin St., Boston, Mass.

I. Fibres (Synthetic and Natural) and Fibre Analysis

Silk Reeling Water: Effects of Salts. T. Nakahara and S. Nisimura. *J. Agric. Chem. Soc. Japan*, 1938, V. 14, P. 843–48, 849–53 (through *Brit. Chem. Abs. B.*, 1938, P. 1138).

When raw silk is reeled with very dilute solutions (0.001–0.0001%) of salts of Fe, Cu, Al, Ca, Mg, Na and K, there is no appreciable effect on the color of the silk, but with 0.01% solutions the whiteness of raw silk is decreased markedly by Fe and Cu, moderately by Al and slightly by Ca, probably due to the adsorption of cation. The lustre of raw silk varies as the amount of fat or loss of sericin on reeling, but there is no relationship between lustre and the effect of salts. (C)

Staple Fibre: Protection from Carbonizing Acids. F. Ohl. *Kunstseide*, 1938, V. 20, P. 266–68; abs. in *J. T. I.*, Nov. 1938, P. A669 (C)

Synthetic Substitutes for Wool. H. F. Crow. *Silk & Rayon*, 1939, Feb., P. 144; May, P. 416–17.

A review of recent developments. (C)

"Tiolan" Casein Fibre: Production. *Kunstseide*, 1938, V. 20, P. 347–50; abs. in *J. T. I.*, Dec. 1938, P. A724.

The state of the German dairy industry and the utilization of skim milk and other waste products are discussed. Reference is made to Italian

Lanital fibre and a general account is given of the production in Germany of a similar casein fibre known as Tiolan. The composition and properties of this product are compared with those of wool and it is claimed that Tiolan has good heat insulating and felting powers and a soft, full handle, has a strength approaching that of wool, and is superior to wool in elasticity and resistance to attack by moths. Applications of Tiolan are discussed and samples of fibre and fabric are given. (C)

VISCOSE: DECOMPOSITION VELOCITY IN SPINNING PROCESS. R. Inoue. *J. Soc. Chem. Ind. Japan*, 1938, V. 41, P. 334B–37B; abs. in *J. T. I.*, Feb. 1939, P. A89. (C)

VISCOSE: RIPENING. L. Bonnet. *L'Ind. Text.*, 1938, V. 55, P. 340–42, 445–47, 493–95, 548–50; abs. in *J. T. I.*, March 1939, P. A148.

Various theories of the ripening of viscose are reviewed and methods of determining sulphide content are critically discussed. (C)

WOOL QUALITY AND FINENESS. B. H. Wilsdon. *Mell. Textilber.*, 1938, V. 19, P. 777; *Eng. Ed.*, No. 4, P. 161; abs. in *J. T. I.*, Feb. 1939, P. A124.

Proposals by Bernhardt (*J. T. I.*, 1938, P. A363) to establish a definitive relationship between measurements of wool fineness and accepted designations of wool quality are referred to. It is pointed out that while the International Wool Textile Organization has adopted as one of its primary objectives the drawing up of standard methods, based on generally recognized procedures, which would serve to measure independently all the characteristics of wool entering into the assessment of quality, it was decided at the London Conference (June 1938) that it was undesirable, in view of the many separate characteristics which enter into the assessment of quality and the arbitrary nature of conventional grades, to place wool quality and fineness into direct relation with one another. Unavoidable sampling and experimental errors make it advisable to avoid any system of differentiation based on rigid grade boundaries. It was also decided that any satisfactory type of apparatus would be recognized for measuring fineness in cases of arbitration. (C)

(WOOL) YIELD DETERMINATION. U. Neuhaus. *Z. f. Züchtung, B*, 1938, V. 41, P. 326–52; abs. in *J. T. I.*, Feb. 1939, P. A125.

A suggested method of obtaining the yield of the fleece is to take four sub-samples from shoulder, side, leg and back. It has been shown by examining 100 fleeces that the method gives results with only very small deviations from the actual yield. Using the same flock the question of correlation between fineness and yield was investigated, the results showing that no such relationship existed within a flock. (C)

II. YARNS AND FABRICS

CENTRE SELVEDGE MECHANISM. A. Schejnoha. *Spinner u. Weber*, 1938, V. 56, No. 38, P. 1–4; abs. in *J. T. I.*, Dec. 1938, P. A734.

A device for the production of firm centre selvedges when weaving bordered goods, such as shawls, side by side on wide looms is described and

shown in diagrams. The device employs two half healds with glass eyes for the control of crossing threads each of which crosses two ground warp threads. (C)

CLINGING POWER OF SINGLE COTTON FIBRES IN RELATION TO THEIR PHYSICAL PROPERTIES. K. R. Sen and N. Ahmad. Indian Central Cotton Committee Technological Laboratory, Matunga, Bombay, India, Technological Bulletin Series B, No. 25, Dec. 1938, 24 pp.

This investigation was carried out with a new apparatus designed for the purpose of measuring accurately the clinging power of cotton fibres at different angles of slippage. Among the important conclusions drawn from the data obtained are the following: (1) The fibres of a coarse cotton possess rougher surface than those of a fine cotton. Beyond a certain limit of coarseness the roughness of surface increases at a greater rate than the coarseness. Inversely, above a certain degree of fineness, roughness of fibre surface alters very slowly. (2) The extent to which clinging power may be expected to increase with the number of convolutions per inch is largely offset by the irregularity of spacing of the convolutions and the distributions of surface corrugations. (3) Up to a limit the intrinsic clinging power increases with the amount of wax per unit surface. Beyond this limit it assumes a more or less steady value. The implications of these phenomena are discussed. (4) High humidities tend to reduce clinging power. A similar effect is produced by low temperatures. It is probable that these phenomena are caused by alteration in the amount of moisture residing on the fibre surface. (5) At low pressures between the pads the coefficient of friction generally decreases as pressure is increased. This is probably due to imperfect contact. Good contact is established at a pressure ranging between 5 and 6 cms. of mercury for different cottons; beyond this point the coefficient of friction assumes a fairly steady value. (6) Previous swelling in alkali reduces the clinging power and also renders it less variable. (7) The clinging power increases significantly when the wax is removed from the fibre. It is highly probable that this increase in clinging power is the action of freshly revealed surface corrugations which were previously hidden under wax deposits. (C)

CLOTH: HYGIENIC PROPERTIES. H. Sommer. *Kunstseide*, 1938, V. 20, P. 439–44; abs. in *J. T. I.*, March 1939, P. A190.

Under hygienic properties of cloth are included thermal insulating power, water-repelling properties, air permeability in the dry and wet states, and permeability to water vapor. Methods of measuring these properties are outlined and the effects of various factors such as thickness and porosity are discussed. The effects of mixing staple fibre and shoddy with the wool from which the cloth is made are studied. It is shown that it is possible to obtain from such mixtures cloth having hygienic properties as good as those of woolen cloth provided that a large pore volume is ensured by using shoddy or staple fibre with a permanent crimp and avoiding treatments causing compression, and that the wettability of these fibres of high swelling power is reduced by suitable impregnations without damaging their power of absorbing moisture. (C)

COLOR MATCHING AND GRADING: STANDARDIZED DAYLIGHT TO CONTROL. *Rayon Tex. Mo.*, Feb. 1939, P. 66–8. (C)

CONSUMER SPECIFICATIONS FOR SIX CLASSES OF HOUSEHOLD BLANKETS: SUGGESTED. Margaret B. Hayes. *Rayon Tex. Mo.*, Feb. 1939, P. 71–3.

The author states that "classification and an established standard of the kind here proposed would help the shopper to judge hidden value and enable her to obtain the kind of blanket she needs at a price she can afford," also that "the information may be given in the form of a factual label of the type suggested by the Consumer-Retailer Relations Council, or by stating that the blanket meets the requirement for a specific class of blanket as established by an association such as the American Society for Testing Materials." (C)

CONTINENTAL TYPE INTERSECTING GILL-BOXES. Prince-Smith and Stells, Ltd. *Tex. Mfr.*, Mar. 1939, P. 109–10.

Describes constructional improvements in a new design of Continental type intersecting gills which are used in many operations in worsted combing and drawing on the French or A. C. systems. (C)

III. CHEMICAL AND OTHER PROCESSING (NOT OTHERWISE CLASSIFIED)

OXIDATION AND REDUCTION IN TEXTILE FINISHING. Karl Volz. *Mell. Textilber.*, 1938, No. 12, P. 986.

A distinction is drawn between oxidation bleaching and reduction bleaching, according to the effect of the bleaching agents used. The author describes the effect of the oxidation bleaching agents. The reduction bleach has not acquired the importance of the oxidation bleach and it is chiefly used for bleaching animal fibres. The oldest form of the reduction bleach is the use of burning sulphur in the stoving chamber in the presence of moisture. Oxidation is to be met with in dyeing in the process of diazotizing (where it might perhaps hardly be suspected), in diazotizing after-treated direct dyeings followed by developing, in coupling with a diazo compound, *e.g.*, of para-nitraniline, in dyeing insoluble azo colors, and in coupling the napthol prepare with the diazo compound of the diazotized color base. After-treatment of direct dyes and treatment of sulphur dyes with bichromate and acetic acid are based upon a process of oxidation and chromium is simultaneously bound by the dyestuff. We further meet with an oxidation process in the dyeing of aniline black. Reduction plays a leading part in the dyeing of vat dyes and of those sulphur dyes that can be vatted. The dyeing of the Indigosol dyes is connected with the dyeing of vat dyes. Oxidation and reduction have always been of great importance in cloth printing, especially in discharge printing, and a distinction is drawn between oxidation and reduction discharges according to the colors to be discharged and the mordants, beside which alkaline and acid discharges are of relatively less importance. Finally, oxidation and reduction form the basis of the stripping of colors, for which purpose there is no universal agent in existence and no universal process. Bleaching with hypochlorite, that is to say, oxidation, is applied for stripping dyeings on vegetable fibres. The actual stripping agents for dyeings are the various brands of Decrolin, zinc sulphoxylate-aldehyde double compounds, which are primary or secondary zinc salts

of oxymethane sulphinic acid. They act in a hot or boiling acid liquor and may be used for all types of fibres, especially animal fibres, and mixtures thereof. (C)

PERMANENT FINISHING OF CELLULOSIC FABRICS. C. L. Wall. *Text. Mfr.*, 1938, Nov., P. 492–3; Dec., P. 540–1, 546.

A general discussion of the basic factors in the progress toward permanency of finish, and the requirements in actual processing, and the routine of processing. (C)

PERMANENT FINISHES. R. J. Smith. *J. Soc. Dyers Col.*, Sept. 1938, P. 407–13; abs. in *Am. Dye. Rptr.*, Oct. 31, 1938, P. 605–6, 628–30.

The author holds that the word "permanent" is becoming almost as ill-used and ill-applied as the words "fast" and "fadeless" in connection with colored textiles. He suggests before it is too late, it might be advisable to consider the use of a description, *e.g.*, "durable finishes," less liable to give rise to claims difficult to support. The durable finishes which he describes include a most extensive series of finishes of several types, which may be divided into three classes, *viz.*, (1) those produced by mechanical means alone; (2) those dependent upon deposition of substances within or upon the material; and (3) those resulting from chemical modification of the fibres forming the fabric. (C)

PLASTICS IN THE CHEMICAL PROCESSING OF TEXTILES: GROWING USE OF. Julian Warwick. *Text. Col.*, Sept. 1938, P. 587–92. (C)

PRINTING COTTON AND RAYON FABRICS WITH COLORLESS AND WEAKLY COLORED PRINTING PASTES: SIGHTING DOCTOR STREAKS, ETC., IN. *Mell. Teltilber.*, 1938, V. 19, P. 442; abs. in *J. Soc. Dyers Col.*, Aug. 1938, P. 402.

Describes three methods for rendering visible faults of the type of doctor streaks in printing cotton and rayon fabrics. (C)

PROTEINS IN THE SERVICE OF TEXTILE CHEMISTRY. J. Wakelin. *Text. Col.*, 1938, Aug., P. 515–7; Sept., P. 596–8. (C)

RAWSTOCK DYEING OF CUT STAPLE RAYON. Wm. G. Ware. *Am. Dye. Rptr.*, Dec. 26, 1938, P. 768–70.

Paper presented before Southeastern Section, A. A. T. C. C., Sept. 10, 1938. (C)

RAYON PROCESSING TECHNIQUE. J. E. Meili. *Canadian Text. J.*, Oct. 28, 1938, P. 39–40, 50.

Second installment of a paper on "Preparing, Dyeing and Finishing of Vegetable Fibres," delivered at the Summer School of the Canadian A. T. C. C. This installment covers structure of rayon fibre related to yarn and cloth dyeing and printing processes with notes on treatment of staple fibre. (C)

RESISTS UNDER MERCERIZATION. O. Metzger and L. M. Granderye. Sealed Communication No. 2012 of July 12, 1910. *Bull. Soc. Ind. Mulhouse*, 1938, V. 104, P. 70–3; abs. in *J. Soc. Dyers Col.*, June 1938, P. 292.

Cotton is printed with a turpentine (200 g.) solution of colophony (100–200 g.) containing 700–600 g. gum (3:10) as thickener and then dried. The colophony protects the fibre from the action of caustic soda (46° Tw. at 35° C. for 7½ sec.) during mercerization, but the protection is only partial, because during mercerization and the first washing (13½ sec.) some of the colophony is removed and slight mercerization of the printed portions of the fibre occurs. Well-defined prints are obtained on dyeing subsequently with direct dyes. A. Scherrer confirms the above. (C)

STAPLE FIBRE MUSLIN: INCREASING WET-STRENGTH BY THIOUREA-FORMALDEHYDE RESIN. Y. Konisi. *J. Soc. Chem. Ind. Japan*, 1938, V. 41, P. 107–8B; abs. in *J. T. I.*, Aug. 1938, P. A488.

By steeping in a solution of thiourea formaldehyde, a certain optimum amount of ammonium chloride and ethylenediamine (as catalyst), and heating the expressed cloth at 100° C., the author has increased the wet-strength of viscose staple fibre muslin (2-cm. strip) from 7.2 to 16.9 kilog. (dry strength 14.7 kg.). (C)

STAPLE FIBRE AND STAPLE FIBRE-WOOL MIXTURES: DYEING. W. Pflumm. *Deutsche Fäber-Z.*, 1938, V. 74, P. 349–50; abs. in *J. T. I.*, Oct. 1938, P. A601.

Difficulties experienced in the dyeing of staple fibre and staple fibre-wool mixtures in the form of loose fibre, as yarn wound on bobbins and beams, and in fabric form are discussed and necessary precautions are indicated. Suitable methods for the preliminary treatment and dyeing of staple fibre and staple fibre-wool fabrics are outlined. (C)

SULPHAMIC ACID: PRODUCTION AND APPLICATION IN FLAME-PROOFING. M. E. Cupery. *Ind. Eng. Chem.*, 1938, V. 30, P. 627–31; abs. in *J. T. I.*, Sept. 1938, P. A539.

A new process for the production of sulphamic acid, HSO_3NH_2, is based on the reaction of urea with fuming sulphuric acid. The properties of the acid are described in detail. Its salts are suggested as flame-proofing agents for fabrics, papers, etc. The special feature of ammonium sulphamate is that it does not cause stiffening, or adversely affect the handle of fabrics or show tendency to effloresce to the surface on prolonged storage. Sulphamates are not removed by dry cleaning treatments. (C)

SYNTHETIC DETERGENTS: VALUE OF. Harold L. Jones. *Am. Dye. Rptr.*, Oct. 31, 1938, P. 621–4.

Paper presented before Philadelphia Section, A. A. T. C. C., April 22, 1938. (C)

TEXTILE PRINTING PASTES: MEASURING STICK FOR. W. H. Cady. *Am. Dye. Rptr.*, Oct. 17, 1938, P. 569–71. (C)

IV. Research Methods and Apparatus

Test Methods for Rayon Staple Fibres and Spun Rayon Yarns. H. DeW. Smith. *Rayon Tex. Mo.*, 1938, Nov., P. 76–8; Dec., P. 65–7.

Paper presented at the 1938 Fall Meeting of A. S. T. M. (C)

Testing Fabrics (for Abrasive Wear): New Method of. Josef Anderlitschka. *Mell. Textilber.*, 1938, No. 11, P. 899–901.

The author has discovered a new test method and a suitable instrument by means of which the chief components (abrasion of tensile strength, elasticity, and bending) are determined by a number in one single operation on a single machine. The details of the apparatus are fully described. The author in conclusion gives the results of tests which show that the figure ascertained by means of the apparatus actually represents a figure of practical value. (C)

Testing Spun Yarns and Fabrics: Methods of. H. Sommer. *Text. Mfr.*, Sept. 1938, P. 380–2.

A review of new and improved German methods and devices for textile testing. (C)

Testing of Textile Fabrics. Robert H. Adams. *Am. Dye. Rptr.*, Nov. 28, 1938, P. 703.

Paper presented at Technical Session of Atlanta meeting of A. A. T. C. C. "The three principal elements which affect the testing of textile fabrics are considered: namely, the human element, mechanical factors and atmospheric conditions." (C)

Textile Test Methods and Specifications in the Light of Modern Needs. Harry A. Mereness. *Rayon Tex. Mo.*, Sept. 1938, P. 110, 118.

Discusses the question of whether or not textile test methods are sufficient for the public need. (C)

Viscose and Bemberg Rayon: Staining Test. J. A. Radley. *Analyst*, 1938, V. 63, P. 266; abs. in *J. T. I.*, July 1938, P. A425.

Viscose and Bemberg rayons may be readily distinguished in ultraviolet light after staining with Acronol yellow TS. Bemberg rayon fluoresces with a brilliant bluish color but viscose rayon appears a dull blue. Cellulose acetate treated in this way shows a luminous violet-blue fluorescence. An alternative stain is Primuline AS; viscose rayon exhibits a brilliant bluish-white and Bemberg rayon a vivid canary yellow fluorescence. (C)

Waterproofing: Measurement of. T. Hennig. *Mell. Textilber.*, 1939, No. 1, P. 87–8.

Test strips of the impregnated fabric were completely immersed and vertically suspended for some time in a dyestuff solution which penetrated more rapidly into the fabric and the fibre when impregnation was deficient. The solution chiefly used for the purpose contained 0.2 g. Methy-

lene Blue B per litre and the sample was immersed for from 10 minutes to one hour, preferably for 20 minutes. After immersion, the strips were rinsed with water to free them from any dyestuff solution adhering to the surface. The dry strips should be kept as far as possible in the dark to prevent the dye from fading and are measured by the Pulfrich photometer according to Zeiss by the arrangement used for measuring lustre. The test described suggests a slight alteration of the tray test. By substituting a dilute dyestuff solution for pure water, the wetting and penetration of the cloth can be more easily recognized. (C)

WATERPROOFNESS: TESTING OF TEXTILES FOR. Walter M. Scott. *Am. Dye. Rptr.*, Sept. 5, 1938, P. 479–82.

The author discusses and indicates tests that are available or needed for the following three types of water resistance of proofed fabrics: Strong resistance to water under pressure; moderate resistance to penetration by falling water, such as rain; resistance to actual wetting by water. (C)

WETTING AGENTS: A. A. T. C. C. OFFICIAL METHOD FOR THE EVALUATION OF. Carl Z. Draves. *Am. Dye. Rptr.*, Nov. 28, 1938, P. 704.

Paper presented at Technical Session of Atlanta, Ga., meeting of A. A. T. C. C. "The convenience and accuracy of the official method in comparison with the canvas disc method; the adaptation of the official method given in the 1938 Year Book for use with very dilute solutions of wetting agents." (C)

WETTING AGENTS: TESTING. J. Riere. *Tiba*, 1938, V. 16, P. 193–201, 245–51; abs. in *J. T. I.*, Sept. 1938, P. A535.

Methods for the evaluation of wetting agents based on determinations of (1) surface tension, (2) wetting power, and (3) content of active products are reviewed and methods of determining foaming power and resistance to hydrolysis are outlined. The characteristics required in wetting agents for use in bleaching, mercerizing, dyeing and finishing processes are described and a scheme for the examination of a textile assistant is presented. (C)

WETTING AGENTS IN TEXTILE PROCESSING. PART II.—MODIFIED HERBIG APPARATUS. R. B. Forster, I. S. Uppal and K. Venkataraman. *J. Soc. Dyers Col.*, Oct. 1938, P. 465–72.

Description of the advantages and operation of the Herbig apparatus as modified by Evans for the evaluation of wetting power. (C)

WOOL GROWTH AND QUALITY: INFLUENCE OF NUTRITIONAL AND CLIMATIC FACTORS ON. II. LABORATORY METHODS USED IN MEASUREMENT OF WOOL CHARACTERS. P. Larose and A. S. Tweedie. *Canadian J. Rsch.*, 1938, V. 16D, P. 166–73; abs. in *J. T. I.*, Oct. 1938, P. A573.

Samples from sheep used to investigate the effect of various environmental factors on wool growth and quality were examined at the National Research Council laboratories, Ottawa. The determination of crimp, staple length, fibre length, tensile strength, elongation, fibre diameter,

moisture content, wool wax, suint, dirt, and clean wool yield is described. The methods for the measurement of fibre diameter and for the determination of wool wax, suint, dirt, and clean wool involved new technique, and are described in greater detail. (C)

V. Pure Science, Economics and Misc.

Pentosans and Pentoses: Detection and Determination. A. J. Bailey. *Mikrochemica Acta*, 1937, V. 2, P. 35–46; abs. in *J. T. I.*, Aug. 1938, P. A509.

Qualitative tests depending on crystal habit, optical properties and physical constants of pentoses and their derivatives are suggested as the basis of a scheme of identification. The pentosan determination that depends on conversion into furfuraldehyde and precipitation of this with thiobarbituric acid is developed as a micro-procedure. (C)

Protein Degradation Products: Determination. W. Haarmann. *Biochem. Z.*, 1938, V. 296, P. 121–30; abs. in *J. T. I.*, July 1938, P. A439.

Attention is called to the utility of Kober's method (1912–1917) for the iodimetric determination of protein degradation products and refinements of technique are described in detail. The method depends essentially on the fact that alkaline copper hydroxide precipitates protein but forms soluble complex compounds with peptides and amino-acids. (C)

Reciprocal Trade Agreements: Do They Help the Textile Industry? Elvin H. Killheffer. *Am. Dye. Rptr.*, Nov. 28, 1938, P. 691–2. (C)

Research Itself Now a Major Industry. Ernest B. Benger. *Text. Col.*, Oct. 1938, P. 672–5.

Address by general assistant chemical director of E. I. du Pont de Nemours & Co., before the 19th Annual Convention of American Trade Association Executives, Sept. 22, 1938. (C)

Research—A Need of the Industry, an Objective of A. A. T. C. C. Aiban Eavenson. *Cotton*, May 1938, P. 71–3. (C)

Starch: Composition. M. Samec and M. Bline. *Kolloid Beihefte*, 1937, V. 47, P. 371–472; abs. in *J. T. I.*, Aug. 1938, P. A510.

Work on the composition of the starch grain by the authors and others during the last twenty years is exhaustively reviewed under the following headings: (1) fractionation of the granule constituents; (2) phosphoric acid systems; (3) phosphoric acid-nitrogen systems; (4) fatty acid systerms; (5) the silicic acid system; (6) comparison of the amylo- and erythro-substances; (7) the amylopectin question and (8) details of experimental work cited in the foregoing discussion. (C)

Starch: Mechanical Disruption and Dispersion of. H. Brandenburger. *Text. Mfr.*, Sept. 1938, P. 396.

Abstract of a paper presented before the International Society of Chemists and Colourists at Dresden by H. Brandenburger, in which he described a method of mechanical disruption and dispersion of starch as a

finishing or sizing solution and its advantages. The method of treatment apparently consists of a disintegrator and homogenizer. (C)

SURFACE FILMS: ELECTROCAPILLARY THEORY AND PH. S. R. Craxford, O. Gatty and T. Teorell. *Phil. Mag.*, 1938, V. 25, P. 1041–61; 1061–6; abs. in *J. T. I.*, Sept. 1938, P. A561. (C)

SURFACE TENSION: MEASUREMENT. V. Naggiar. *C. R. Acad. Sci.*, 1938, V. 206, P. 1882–4; abs. in *J. T. I.*, Sept. 1938, P. A562.

A method for measuring the surface tension of liquids is described that gives results within 1%. (C)

TECHNICAL RESEARCH: GROWING IMPORTANCE OF. J. E. Bullard. *Rayon Tex. Mo.*, Nov. 1938, P. 37–8. (C)

TEXTILE FOUNDATION RESEARCH PROGRAM AT THE NATIONAL BUREAU OF STANDARDS. Milton Harris. *Am. Dye. Rptr.*, Nov. 28, 1938, P. 703.

Paper presented at Technical Session of Atlanta meeting of A. A. T. C. C. "The aim of the new research program of the Textile Foundation at the National Bureau of Standards is to obtain fundamental data on the chemical and physical chemical properties of textile fibres. It is intended that such data will form a background for the study of many of the problems in textile processing. The work which is being undertaken is divided into cellulosic fibre investigations dealing with cotton and rayon and protein fibre investigations dealing with silk and wool. The following investigations are now in progress: a study of the acidic and basic properties of silk, wool, and cellulosic fibres, the polyuronides in cellulose and their relation to fibre structure, the effect of oxidizing agents on cellulose, the cell structure of wool, the effect of oxidizing and reducing agents on wool, a study of the reactive groups in silk, the electrophoretic properties of textile fibres, and a microscopic study of the structure of the fibres. A brief discussion of these projects and their relation to practical processing problems was presented." (C)

VERTICAL INTEGRATION: MILL MANAGEMENT BY. Henry P. Kendall. *Text. Bulletin*, Oct. 15, 1938, P. 13–4, 43–5.

This paper, presented at the Seventh International Management Congress is summarized by the author as follows: "The paper declares the combination of line and staff, with decentralized operating divisions, to have been a sound adaptation of functional management, giving 'an administration flexible, alert and one in which maximum growth of individual executives is permitted.'" (C)

VISCOSITY OF DILUTE SOLUTIONS OF LONG-CHAIN MOLECULES. M. L. Huggins. *J. Phys. Chem.*, Oct. 1938, P. 911–9; abs. in *Eastman Kodak Abs. Bull.*, Nov. 1938.

Communication No. 647. By an extension of Kuhn's hydrodynamical treatment, a theoretical equation has been derived relating the specific viscosity of a solution to the co-ordinates and dimensions of the atoms in the solute molecules. (S)